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THE AVOCADO

ITS INSECT ENEMIES AND HOW TO COMBAT THEM

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PRACTICALLY EVERY CROP, be it fruit, vegetable, or flower, has an insect enemy, or more than one, apparently bent on its destruction. The avocado is no exception to the rule. It is attacked by several insect pests which at times cause concern to the producer of this valued and highly nutritive fruit. These insects are often responsible for reductions in yield and quality of fruit, but such losses are largely preventable. Often the damage caused by the insects is gradual and it is only the resultant injury that is conspicuous. *It is essential, therefore, that the avocado grower watch his trees carefully for evidences of insect injury and apply remedies promptly.*

The principal insect pests of the avocado occurring in Florida at the present time are the dictyospermum scale, the avocado white fly, the pyriform scale, the blossom Anomala, the avocado lace-bug, the avocado blossom thrips, the avocado leaf-roller, the avocado red spider, and the avocado leaf-infesting thrips. Brief descriptions of these pests, of their life histories, and of the means found most effective, in each case, for combating them are given in this bulletin.

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C. April, 1922

THE AVOCADO: ITS INSECT ENEMIES AND HOW TO COMBAT THEM.

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ALL VARIETIES OF AVOCADO SUBJECT TO INSECT ATTACK.

AVOCADO GROWING was established a number of years earlier in Florida than in California, and for this reason considerably more is known about this fruit and its insect enemies in Florida than on the Pacific coast. To those who are growing the avocado in California, however, a discussion of its insect pests in Florida, where the investigations upon which this paper is based were conducted, may not be without interest. Although conditions must largely decide methods and practices in the control of avocado pests, the experience gained in another region can not fail to throw light on certain questions which may arise in California.

The avocados now grown in Florida are mainly varieties of the West Indian race, although varieties of the Guatemalan type are fast gaining in popularity among growers, due to the fact that they will stand a somewhat lower temperature. The Guatemalan race, however, has been grown sufficiently in Florida to show that for the most part the insects which attack the West Indian race of avocado will adapt themselves to the hardier Guatemalan varieties as well. While some of these insect enemies may have been introduced, others probably have long been present on native vegetation and have recently adapted themselves to the newly imported and more attractive avocado.

INJURIOUS INSECTS OF THE AVOCADO IN FLORIDA.

THE DICTYOSPERMUM SCALE.[1]

The avocado, as is the case with deciduous fruits and citrus fruits, has its destructive scale enemies, the most important of which, in Florida, is the dictyospermum scale. The adult scales (fig. 1, *a*) are circular, or slightly elongated, closely resembling other scales of a similar nature. They vary in color from a light yellow to a reddish brown.

CHARACTER OF INJURY.

The dictyospermum scale is a pest in the avocado nursery as well as in the bearing grove and has been found to infest both the West Indian and Guatemalan races of avocados. In the nursery it finds special protection where the trees are crowded together in blocks. In the grove it attacks the twigs and branches and, where numerous, the foliage. The branches so attacked (fig. 1, *b*) are gradually weakened and ultimately become of little use to the tree. The branches at the base of the tree are generally attacked more severely, being more protected from the elements than those toward the top (fig. 3). Where trees have been seriously attacked they in time assume a nude appearance, due to the destruction of the foliage-bearing twigs and branches. Branches and twigs severely infested soon become roughened and crack considerably, affording entrance places for various destructive fungi (fig. 2).

LIFE HISTORY AND DEVELOPMENT OF THE SCALE.

The young of the dictyospermum scale insect are hatched beneath the scale which covers the adult female. They are broadly oval in outline and yellow in color. They are much flattened creatures, provided with six legs, a pair of antennæ, and an apparatus for sucking the juices from the tree. They are exceedingly small, appearing as mere yellow particles. They remain beneath the scale covering a short time and after emerging crawl over the branches and twigs and soon settle down and begin their growth, living at the sole expense of the tree.

Several days after settling the young scale assumes a circular shape and begins to exude a mass of fine white cottony threads which finally cover the entire insect. About four days after birth the scale covering commences to change again, and the cotton-appearing substance is cast away for a more compact scale or nipple-like covering, the center of which is whitish with a grayish tinge, with white outer edges. Underneath this scale covering the insect grows and goes through the process of molting several times. With the first molt the legs and antennæ are shed with the skin. The young

[1] *Chrysomphalus dictyospermi* Morgan.

insect beneath the scale thus becomes a degraded saclike creature, with no organs of locomotion. The mouthparts remain, however, in a highly developed state. They consist of delicate hairlike bristles

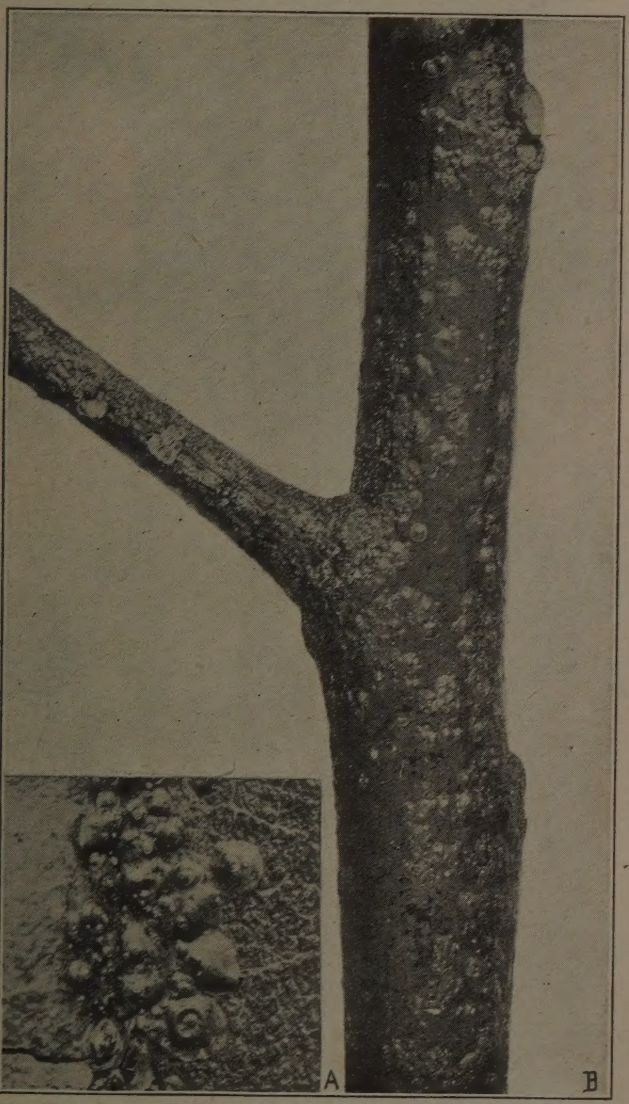

FIG. 1.—The dictyospermum scale: *a*, Scales, enlarged eight times; *b*, scales on twig, slightly enlarged.

by means of which the insect is firmly attached to the tree from which it draws its nourishment. Underneath this scale covering the insect remains fixed throughout its existence. On reaching maturity

FIG. 2.—The dictyospermum scale: Branch of avocado with bark cracked due to work of scales, thus affording entrance places for fungi.

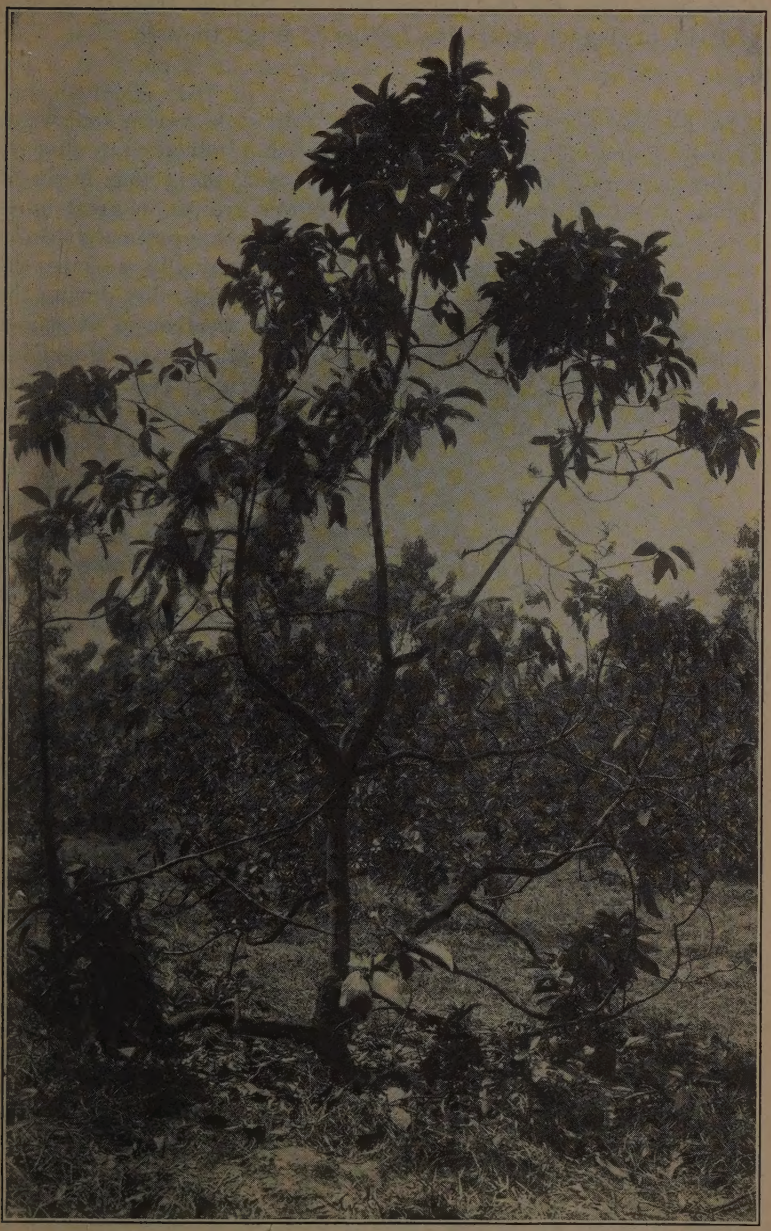

FIG. 3.—The dictyospermum scale: Infested tree showing destruction of twigs and branches and nude appearance.

it produces eggs, and the young which are hatched from these eggs give rise to another generation further to infest the tree.

SEASONAL HISTORY.

In Florida the seasonal history of this scale varies somewhat, depending upon the locality, its activities being influenced by changes of temperature. As a general rule, however, the young begin to appear about March 1 and infest the newer growth in great numbers. At this time of year a generation requires approximately seven weeks to mature. As the weather becomes gradually warmer, the generations are a little shorter, and overlap considerably during the summer months. With the approach of cool weather in December and January a generation lengthens and requires over two and a half months in which to develop. In southern Florida, depending upon the locality, this scale may pass through from five to six generations in a year.

HOW THE SCALE MAY BE CONTROLLED.

The best time to control the dictyospermum scale on the avocado is when the trees are dormant, from the middle of December until the 1st of February. Oil emulsions, such as are used against citrus insects, have been found to control the scale effectively. There are a number of oil emulsions on the market, some of which when combined with waters used in spraying in Florida work very satisfactorily. The waters used in southern Florida for spraying purposes are those which come from deep wells in limestone formation and are termed "hard," and those which come from surface wells and are as a rule somewhat brackish. Certain oil emulsions, however, when combined with these "hard" waters may prove at times unsatisfactory, because the lime and magnesium salts usually present in the water tend to break up the emulsion, causing the oil to be set free during spraying. If separation occurs in using an oil emulsion with the water, the water should be first softened by means of caustic potash fish-oil soap. Two to three pounds of caustic potash fish-oil soap to a 125-gallon tank have been found sufficient to soften the ordinary hard water. After the water has been so softened the oil emulsion should be added. In using the oil emulsions on the avocado during the dormant season, the writer has found that a strength of 1 gallon to 70 gallons of water proved the most satisfactory. Two applications with a three-week interval during the dormant period will control this scale insect. In the nursery a strength of 1 gallon to 80 gallons of water should be used on account of the new growth generally present.

THE AVOCADO WHITE FLY.

A pest which attacks the avocado in Florida is the avocado white fly.[2] It is much smaller than any of the white flies which attack citrus fruits, but is similar in habits. The adults (fig. 4) of this species average less than 1 millimeter (one twenty-fifth inch) in length and possess pale yellow bodies with white wings. This white fly may also be recognized on the foliage by the fact that the pupæ possess a characteristic fringe about the margin (fig. 5). It is quite widely distributed in Florida and is to be found wherever avocados are growing. Apparently it is a native insect and has adapted itself to the avocado as a host. It was first recorded from specimens received from Florida by Dr. A. L. Quaintance. At times the writer has collected it on various weeds and also from papaya, banana, guava, and annona.

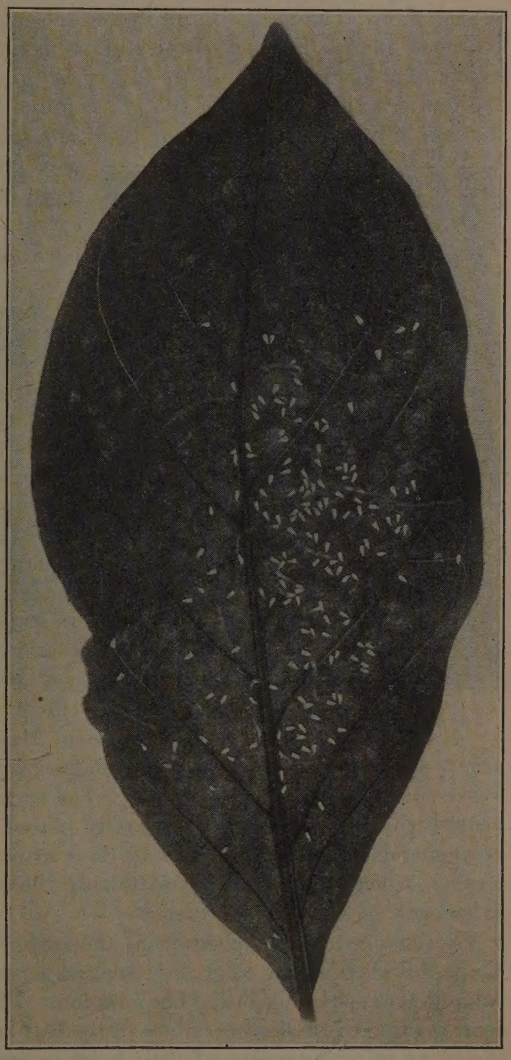

FIG. 4.—The avocado white fly: Adults depositing eggs on lower surface of leaf.

CHARACTER OF INJURY.

The avocado white fly is a pest both in the bearing grove and in the nursery, where it attacks the foliage and also produces honeydew in which the

[2] *Trialeurodes floridensis* Q.

sooty-mold fungus develops, giving the foliage and fruit a blackened appearance (figs. 6 and 7). It attacks both the West Indian and Guatemalan races of avocados. This species is very sensitive to varying changes of temperature and prefers and develops more abundantly in protected places. It is very abundant on trees on the Florida Keys and on islands along the southern coasts of Florida. The direct injury is caused by the white fly in the larval stages extracting the plant juices from the foliage. The indirect injury is caused by the resultant sooty mold on the foliage and fruit. Where this sooty mold is abundant considerable extra labor is required during packing to clean the fruit.

FIG. 5.—The avocado white fly: Pupæ on lower surface of avocado leaf.

SEASONAL HISTORY OF THE WHITE FLY.

During the dormant season of the avocado—December, January, and February—this species is inactive, remaining over on the foliage in the pupa stage (fig. 5). With the beginning of new growth in the spring, its activities commence and the adult is then to be found in great numbers on the new growth, depositing eggs (fig. 4). During the first part of March the adults usually are present and mate, and the females deposit their eggs on the lower surface of the young foliage. The eggs are very small objects, pearly white in color, and are usually placed in circles. During the spring and summer from 8 to 10 days are required for the egg to hatch. About 100 eggs are laid during the little over a week of its existence.

The young when hatched from the eggs are very small, oval in shape, of a yellowish color, and semitransparent, with two orange-colored areas showing in the body region. They soon settle down on some portion of the lower surface of the leaf and commence to extract the plant juices by means of their hairlike mouth parts. The young larvæ molt in about an average of 5 days. As they grow the body becomes more circular in outline, and during the process of growth quantities of honeydew collect on the tops of the individuals. Often these drops of honeydew become many times the size of the insect. The honeydew drops from the body of the larva on to the upper

surface of the foliage or fruit, and the sooty-mold fungus is thus furnished with a medium in which to develop. The second molt of the larvæ occurs in an average of from 5 to 6 days, and the third, in an average of 7 days. The pupa stage during the spring and summer months averages from 15 to 30 days, and during the fall and winter from 3 to 6 months. The successive larval stages are quite similar in general appearance, varying only in size.

There are, on an average, three generations with a partial fourth varying according to locality and temperature conditions, much as in the case of the dictyospermum scale. Toward fall, usually the latter part of October, as the foliage becomes dormant, the white fly ceases its activities and goes into the winter in the pupa stage.

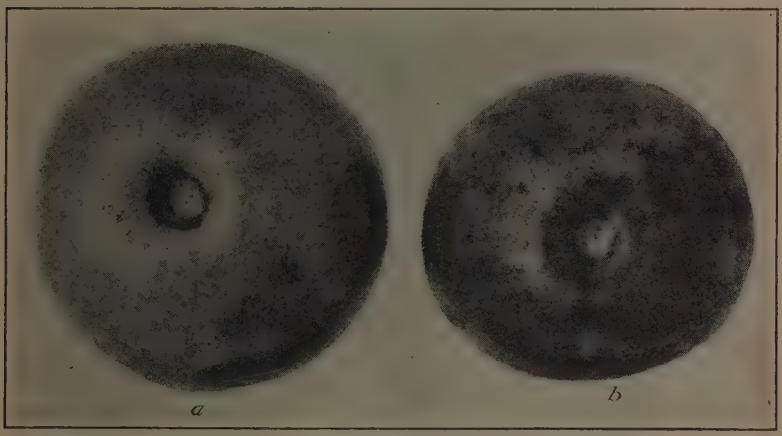

FIG. 6.—The avocado white fly: *a*, Clean fruit; *b*, top of avocado covered with sooty-mold fungus.

HOW IT MAY BE CONTROLLED.

The white fly may be controlled by spraying during the fall with an oil emulsion, preferably just as the foliage is commencing to harden, and repeating the operation some time during the spring after the fruit has set. The fall spraying for white flies should be made with 1 part oil emulsion to 70 parts of water and the spring spray should have the strength of 1 to 80. In spraying for white flies with an oil emulsion it is important that no free oil separates during spraying, and that the spray be directed so as to reach the lower surface of the foliage. Experience has shown that in spraying operations against the white fly spray rods are more satisfactory as it is quite difficult to reach the lower surface of the foliage with the spray gun, because the avocado tree bears branches close to the soil (fig. 8) and the foliage on these branches is more readily reached

FIG. 7.—The avocado white fly: Sooty-mold fungus on upper surface of avocado leaf.

with a spray rod than with a spray gun. Where two applications of oil emulsion are made for the white fly, and the spray is directed toward the twigs and branches which are infested with the scale, it will usually not be necessary to make an additional spray for the dictyospermum scale, provided the branches are well covered.

THE PYRIFORM SCALE.

Another scale insect found occasionally on the avocado in Florida is the pyriform scale.[3] The adult female scale (fig. 9), the stage which is usually observed on the foliage, is slightly convex, pyriform (pear shaped) in outline, transversely corrugated, of a reddish brown color, and about 3 millimeters (one-eighth inch) in length. The cottony matter projecting about the margin of the scale consists of curled waxy filaments. Among the

[3] *Protopulvinaria pyriformis* Ckll.

adult scales may be noted the young. They are small, oval, yellow creatures and do not possess the cottony mass about the margin. The adult male is a very delicate insect. It averages about 2 millimeters in length (one-twelfth inch), has an orange colored body and pale colored legs. The wings are clear and covered with very fine hairs.

CHARACTER OF INJURY.

The scales on the foliage extract the juices from the plant. During the development of the scales there is a rather constant secre-

FIG. 8.—The avocado white fly: Characteristic low branching of avocado tree. Lower branches are generally heavily infested, being more protected from the elements.

tion of honeydew, and frequently an individual scale will be covered with a drop of liquid many times its own size. This honeydew drops from the bodies of the scales onto the upper surface of the foliage and fruit, just as it does with white flies. During the humid summer weather the sooty-mold fungus finds there a suitable medium in which to develop and in course of time gives infested trees a very blackened, sooty appearance. The injury caused by the scale is twofold: Extraction of the plant juices from the foliage and production of honeydew in which the sooty fungus develops, marring the appearance of the foliage and fruit.

SEASONAL HISTORY AND DEVELOPMENT.

During the dormant season of the avocado the pyriform scale is quite inactive. Infested trees during December, January, and February possess foliage covered with the female scales in a half-grown condition, maturity taking place in the spring. In March the female scales form cottony margins, and ultimately hundreds of eggs will be produced within these cottony masses in process of formation beneath the scales. During April the males emerge from those scales which have no evidence of cottony secretions. The writer has observed at various times in southern Florida males in great numbers during the middle and latter part of April. Evidently fertilization takes place at this time. The cottony masses in May are really little bags packed full of minute, yellowish, oval bodies. These are the eggs, and the white covering is merely an egg sac consisting of waxen filaments excreted from the lower surface of the scale. The eggs commence to hatch in great numbers during May, when rows of young scales may be seen upon the under surface along the lateral veins and ribs of the leaves.

FIG. 9.—The pyriform scale: Lower surface of avocado leaf, showing adult scales with characteristic white fringe; also young scales scattered among them, appearing as mere specks.

Many also occur in the interstices of the leaf surface between the veins. The scale spends its entire life cycle on the foliage, only migrating to the twigs in order to reach and reinfest the newer growth. During May and June great numbers of the young scales migrate to the newer growth, but many are lost with the shedding of the older leaves at this time of year. However, a sufficient number become established on the new growth to perpetuate the species. There are several generations in a year, overlapping considerably.

HOW IT MAY BE CONTROLLED.

The same methods as recommended for the dictyospermum scale may be used in the control of this scale, handling the spray rods so as to reach the underside of the foliage and get the spray to the scales.

FIG. 10.—The blossom Anomala: Adult beetles. About 2½ times natural size.

THE BLOSSOM ANOMALA.

When the avocado is in bloom it may be visited in swarms by a beetle, the blossom Anomala, which may cause serious damage. Up to this time the writer has not observed this beetle to be generally distributed at blossoming time, though it may be found present in groves in certain localities, while other groves escape. The following year the infested groves of the previous year may escape, and others may be visited by this blossom-devouring pest. The adult beetle[4] (fig. 10) has a black thorax with a yellowish border, the wing covers yellowish brown, with two cross-rows of ill-defined black spots, sometimes almost wanting. It varies in size from one-fourth to five-sixteenths inch in length. Variations of the color may occur, and the writer has found on a number of occasions nearly black forms. The species is closely related to the so-called May beetles. Up to this time the larva form has not been found.

[4] *Anomala undulata* Mels.

Judging, however, from related species the larvæ must be closely similar, except for their smaller size, to the white grubs, or May beetle larvæ, not only in general appearance but more or less in habits also.

CHARACTER OF INJURY.

When present in groves, these beetles may be found attacking all portions of the blossom spike, in many instances completely stripping the spikes of the individual blossoms (fig. 11). Often the beetles will completely girdle the spike and frequently cut it off as with a knife. Usually the beetles confine their attacks to the more tender floral parts, destroying the individual floral clusters about the spikes. The writer observed that during the day numerous freshly injured floral spikes could be found, but the presence of the destructive pest causing the damage could not be detected about the bloom or anywhere on the trees. It was observed, however, that below the trees numerous small holes were present in the soil. Upon examination it was found that in the soil at a depth of from 1 inch to 2 inches a considerable number of small beetles were present in a quiescent stage as if playing possum. After a few minutes' exposure to the light the beetles became active and immediately dug their way into the soil. Various groves were visited during the dusk and evening, when it was observed that the beetles, found in the soil during the day, were present in great numbers feeding upon the blossom spikes. In other words, the adult beetles are nocturnal in their feeding habits.

FIG. 11.—The blossom Anomala: Showing characteristic stripping of the blossom spikes by the adult beetles.

HOW IT MAY BE CONTROLLED.

The best means of control is to spray the blossom spikes with a poison as soon as any signs of injury to the bloom are detected. By spraying with a solution of 1½ pounds of powdered arsenate of lead to 50 gallons of water the beetles will be killed or forced to seek new feeding grounds. It is essential that the spraying outfit be equipped with a good agitator, as the poison has a tendency to settle rapidly to the bottom of the spray tank unless it is kept in suspension by agitation. The spray should be directed at the blossom parts particularly, as the beetles do not attack the dormant foliage, and little if any new growth is present on the plant at the time of blossoming.

THE AVOCADO LACE-BUG.

An insect which often is on the avocado in considerable numbers during the dry winter months is the avocado lace-bug.[5] The group of insects to which it belongs gets its common name from the characteristic lacelike pattern of the wings (fig. 12). This lace-bug is blackish-brown in color and about 2 millimeters (one-twelfth inch) in length. The wings covering the body are somewhat iridescent and the legs are yellowish white.

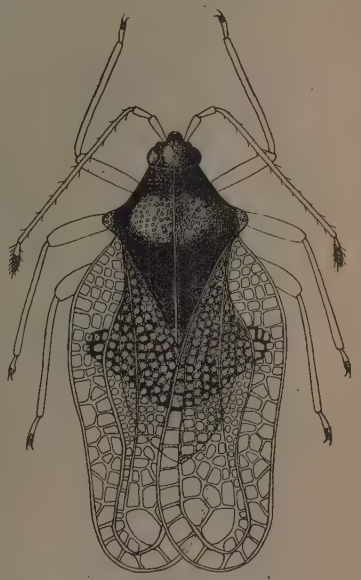

FIG. 12.—The avocado lace-bug: Adult, greatly enlarged.

CHARACTER OF INJURY.

The lace-bug confines its attacks to the lower surface of the foliage, where it feeds by extracting the juices from the plant. It usually lives in colonies, depositing eggs in clusters on the lower surface, which are placed upright in irregular rows. The extraction of the juices from the foliage causes a gradual destruction of the plant cells, resulting in yellow areas which may be observed on the foliage as viewed from above and which indicate the presence of the lace-bugs. Where a colony of these insects is present, the eggs and the lower surface of the leaf are more or less thickly covered by a dark, sticky secretion from the insects (fig. 13). The principal injury, however, is the destruction of the leaf cells due to the sucking habit of the insects.

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[5] *Acysta perseae* Heid.

CONTROL.

By spraying with 40 per cent nicotine sulphate at the rate of 1 part to 900 parts of water, with the addition of 1 or 2 pounds of fish-oil soap to each 50 gallons of the diluted spray solution, the lace-bug is readily controlled. The soap will cause the spray to spread more

FIG. 13.—The avocado lace-bug: Injury to leaf of avocado.

readily over the foliage, to stick, and not to fall off in small drops. If the red spider is present at the same time the lace-bugs are doing their work, the nicotine sulphate solution may be added to the lime-sulphur solution in the same manner as when the leaf-infesting thrips is present.

THE AVOCADO BLOSSOM THRIPS.

During the blossoming period the avocado is visited by a destructive flower thrips.[6] In structural appearance this thrips resembles most other blossom or flower thrips. It averages about a millimeter (one twenty-fifth inch) in length and in general color it is pale yellow. The species was first collected in the mountains at Guadalajara,

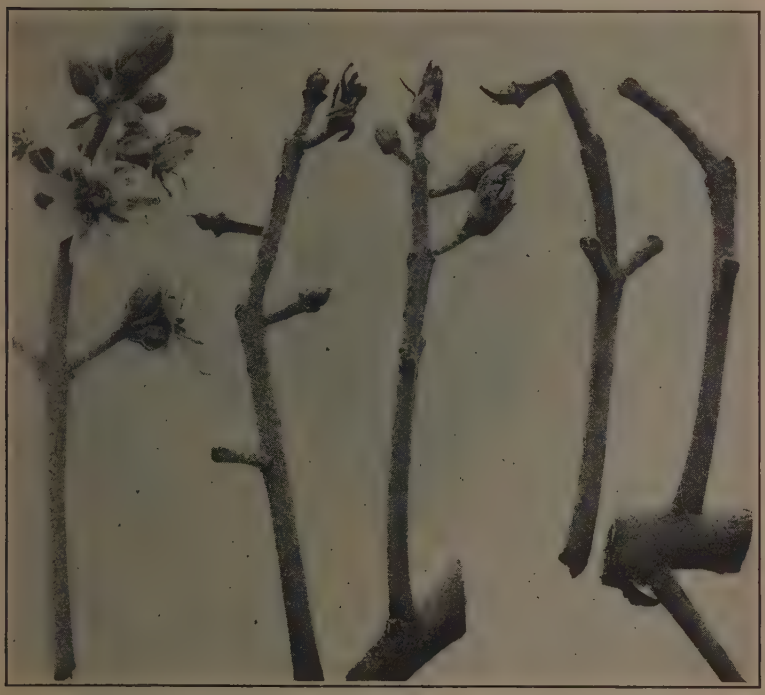

FIG. 14.—The avocado blossom thrips: Showing egg punctures and emergence holes caused by adult thrips in petioles of avocado bloom.

Mexico, on a small native acacialike plant. How it gained entrance to this country is not known.

CHARACTER OF INJURY.

The West Indian varieties of avocado seem to be its favorite hosts, particularly the Pollock and related sorts, although the Guatemalan varieties are also attacked during the blooming period. The thrips work extensively in the flowers, and as they gradually increase they deposit eggs in great numbers in the stems bearing the flower cluster and also in the petioles of the individual flowers (fig. 14). In so doing the petioles supporting the individual flowers are much weak-

[6] *Frankliniella cephalicus* Craw.

ened, and frequently there is a considerable shedding of the bloom due to this work. The principal injury caused by the thrips, however, is due to its feeding on the stamens and the flower parts. The thrips does not attack the fruit.

HOW IT MAY BE CONTROLLED.

The avocado blossom thrips may be controlled by spraying with 40 per cent nicotine sulphate solution at the rate of 1 part to 900 parts of water with the addition of 3 or 4 pounds of soap to each 100 gallons of the diluted spray. The grower should not wait until

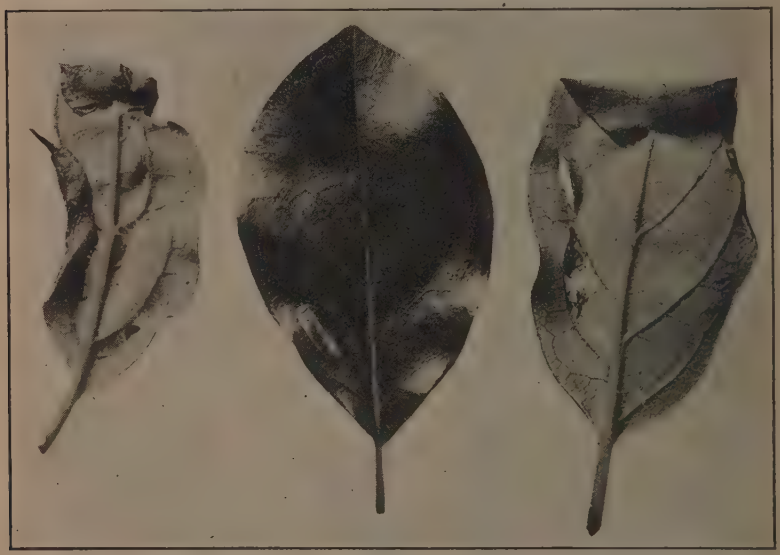

FIG. 15.—The avocado leaf roller: Avocado leaves showing rolling of foliage by the larvæ and cocoons in folds of leaf.

the trees are in full bloom but should start spraying as soon as a number of thrips are observed about the blossom cluster. The spraying should be repeated in from 8 to 10 days, if the thrips are abundant about the bloom. The spraying should be directed so as to enter the blossoms.

THE AVOCADO LEAF-ROLLER.

An insect present on the avocado in June and July is the avocado leaf-roller.[7] It is a very small moth, grayish is color, about one-fourth inch long. It deposits its eggs singly on the new growth, often each young leaf in a terminal cluster bearing a single egg. The young larvæ which emerge from these eggs feed on the lower sur-

[7] *Gracilaria perseae* Busck.

face of the foliage, and in so doing roll the leaves back from the tip (fig. 15). When the larvæ mature they often construct silken cocoons in the folds of the leaf and there pupate. Often where the leaf-rollers have been numerous in the spring, the foliage eventually presents a very ragged appearance.

HOW IT MAY BE CONTROLLED.

Spraying the new growth with powdered arsenate of lead at the rate of 2 pounds to 100 gallons of water has proved successful in controlling the leaf-roller. The spray tank should be fitted with a good agitator, as the poison has a tendency to settle to the bottom if not kept constantly stirred.

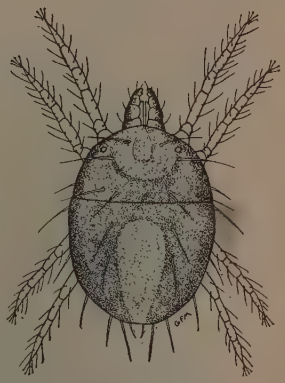

FIG. 16.—The avocado red spider: Adult. Greatly enlarged.

THE AVOCADO RED SPIDER AND THE LEAF-INFESTING THRIPS.

Among the insect pests which attack avocado foliage are two which cause considerable damage during the dry winter months. These two pests are the avocado red spider[8] and a leaf-infesting[9] thrips, commonly known in the North as the greenhouse thrips, but which works on the avocado in the open in Florida. The red spider of the avocado (fig. 16) is similar in shape and appearance to other red spiders, its habits only varying in that it confines its attacks to the upper surface of the foliage. The leaf-infesting thrips is similar to most other thrips, is dark brown in color, and about 1 millimeter (one twenty-fifth inch) in length (fig. 17).

FIG. 17.—The avocado leaf-infesting thrips: Adult. Greatly enlarged. (Drawing by Russell.)

CHARACTER OF INJURY.

In Florida it is usually from the latter part of November until March that the greatest damage is caused to the avocado by the red spider and the leaf thrips. The abundance of either pest

[8] *Tetranychus yothersi* McG.
[9] *Heliothrips haemorrhoidalis* Bouché.

during this period depends chiefly on the existing climatic conditions. Unlike most other red spiders which attack various other fruits, the red spider of the avocado confines its attacks to the upper surface of the foliage. This is also true of the thrips.

Avocado orchards heavily infested with red-spider mites appear in a short time as if scorched by fire. The foliage attacked turns

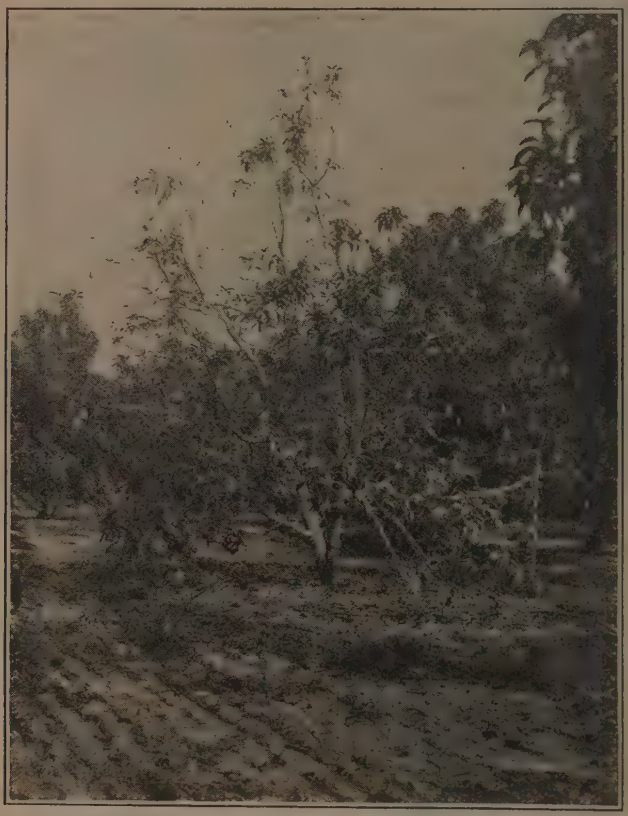

FIG. 18.—The avocado red spider: Defoliation caused by excessive infestation of these mites on avocado tree.

brown and drops prematurely and frequently there is a heavy denudation as a result of their depredations (fig. 18). Their numbers increase so rapidly that the damage caused by the mites and thrips becomes noticeable in a very short period of time. *The grower should not delay spraying until the trees have commenced to turn brown, but should be on the lookout for the pests. Their presence on the trees in excessive numbers should be the signal for the grower to start control measures while the foliage is still green.*

The red spiders and thrips usually start work at the base of the leaf, and as the succeeding generations appear they extend their feeding grounds until the entire leaf is infested. The first indication of red spiders and thrips on the foliage is the pale spots scattered about over the leaf surface. These represent the feeding places, and as

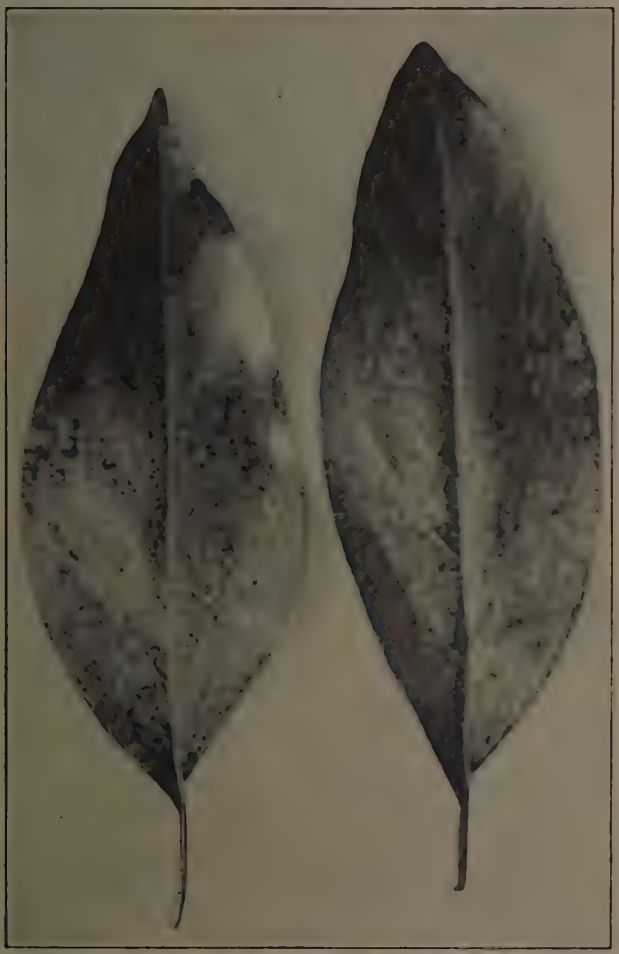

FIG. 19. The avocado leaf infesting thrips. Damage to upper surface of avocado foliage.

they become numerous most of the functional green matter in the leaf is absorbed, and in time such a leaf turns brown and is of little use to the tree. Usually the red spiders and the thrips do not work on the same leaf. The attacks of the thrips have not been found by the writer to be as severe as those of the red spider. The leaf infesting

thrips of the avocado is to be found toward the center of the tree, but also on the outer protected branches. It evidently prefers, and multiplies more rapidly in, the sheltered and protected places. The work of the thrips may be distinguished from that of the red spider in that the surface, in addition to possessing the pale-colored spots where the chlorophyll has been extracted by the thrips, also becomes thickly covered with minute drops of blackish fluid voided by them (fig. 19). Where excessive defoliation takes place, abnormal blooming usually occurs the following spring. Where trees obtain a sufficient amount of water and food of the proper kind, usually less trouble is experienced from the red-spider mite. The avocado requires plenty of water and is a heavy feeder.

HOW THE RED SPIDER AND THRIPS MAY BE CONTROLLED.

If red spiders and thrips become active on the avocado while the fruit is still on the trees in the early fall and are doing serious damage, it will be necessary to spray with fish-oil soap at the rate of 5 pounds to 100 gallons of water, plus 40 per cent nicotine sulphate at the rate of 1 part nicotine sulphate to 900 parts of the diluted soap solution. By so spraying the red spider and thrips will be held in check until after the fruit has been harvested. The soap and nicotine spray is only temporarily effective and does not act against the red spider over a period of several weeks as does the lime-sulphur spray, but as lime-sulphur adheres to the fruit and is difficult to remove, the writer recommends the soap while the fruit is still unpicked.

If the red spiders and thrips become abundant in a young grove which has not reached the bearing age, lime-sulphur concentrate should be used at the rate of 1 part to 60 parts water, plus 40 per cent nicotine sulphate at the rate of 1 part nicotine sulphate to 900 parts of the spray. If thrips are not present, the nicotine sulphate solution should be omitted. In using lime-sulphur solution it is advisable to use a strength of 1 gallon of the concentrate to 75 gallons of water during winters when the temperature is above the normal and when the trees do not attain a thoroughly dormant condition.

Fish-oil soap and nicotine generally afford only temporary relief against the red spiders, and if these mites continue to work after the fruit has been picked, it will be necessary to spray again. During the winter after the foliage has hardened no injury from the use of lime-sulphur as recommended above has been noted by the writer. Where the thrips are not present at this time it will not be necessary to use the nicotine-sulphate solution in combination with the lime-sulphur.

Where an avocado grower contemplates combating white flies and scale insects also during the fall or dormant season, application of the

FIG. 20. Avocado spraying: *a*, Employing spray rods against red spider and leaf thrips; *b*, employing spray gun against the same.

oil-emulsion sprays should be so timed as not to interfere with the lime-sulphur sprays. The oil-emulsion sprays should not be put on immediately following a lime-sulphur spray or foliage injury may be experienced. The two sprays will not mix. The oil emulsions have a cleansing quality and loosen sooty mold, lime, and any foreign matter adhering to the foliage. A great deal of benefit which would have been derived from the lime-sulphur will be lost by applying an oil emulsion over it.

There are a number of ordinary commercial lime-sulphur concentrates on the market which are satisfactory, or the grower can make his own lime-sulphur concentrate if he is prepared to do so. Since the lime-sulphur spray kills the mites largely by contact, it is important that the spray be thoroughly applied in order to reach all of them. This is also true in the case of the thrips when the nicotine sulphate is incorporated with the lime-sulphur spray or is used with the fish-oil soap. From the writer's observations, the lime-sulphur is not effective against the eggs of the red spider, as it kills only a small portion of them. The lime-sulphur is not dependent for its efficiency entirely on contact. Its effectiveness is more or less lasting, and consequently the young which may hatch from eggs not killed will succumb soon after. In about three weeks after spraying avocados for red spiders and thrips another spraying will usually be necessary to protect the trees from further attack. Subsequent applications will depend upon weather conditions and the activities of the pests during the winter season. Usually two sprayings, or three at the most, during the winter will suffice for both the red spiders and thrips.

The writer in comparing the spray gun (fig. 20, *b*) with spray rods (fig. 20, *a*) has found that the spray gun gave better satisfaction, especially on large avocado trees. Where the rods were used, considerable inefficient spraying was done on the upper half of the tree. This was seen to occur especially during the latter part of the day, when the spray rod became heavy to the operator. In spraying the young grove, however, the rods work to a somewhat better advantage.

DUSTING VERSUS SPRAYING FOR THE CONTROL OF THE AVOCADO RED SPIDER AND LEAF THRIPS.

Certain contact insecticides which are being used in the liquid form for combating insects are also being manufactured in the dry powdered form as contact insecticides. These are being manufactured separately, and in combinations to be applied for a number of evils existing at the same time. Recently a number of orchard tests have been made by the writer to ascertain the relative merits of several contact insecticides in the dust or powdered form, alone and

in combination, and similar contact insecticides in the liquid form, in the control of these two pests of the avocado.

In conducting the dusting operations the equipment used was a large power duster (fig. 21), which is provided with a gasoline engine driving a fan capable of rotating approximately 2,500 revolutions per minute and of producing a forced current of air which is directed through the bottom of a hopper holding the dusting material. It picks up the dust particles, forcing the material out through a long pipe and producing a dense, smokelike cloud. The

FIG. 21.—Power duster in operation against red spider on avocado trees.

spraying work was performed the same day, a power outfit being employed, using one of the spray guns (fig. 20, *b*) at a pressure ranging from 225 to 250 pounds. At the time when the materials were applied the foliage was dry and the temperature averaged 75° F.

In the dusting experiments several kinds of material were used, among them an impalpable sulphur dust. This sulphur dust is nearly pure sulphur, very finely pulverized, capable of going through a 200-mesh screen. The other material used was a combination consisting of the above sulphur dust impregnated with a quantity of 40 per cent nicotine-sulphate solution. In the spraying work sev-

eral sprays were tried out in comparison with the foregoing dusts, viz—lime-sulphur concentrate, 1 part to 60 parts water, alone and in combination with 40 per cent nicotine sulphate, at the rate of 1 to 900 in the diluted lime-sulphur solution. A portion of a block was reserved as a check.

Subsequent examination of the dusted and sprayed portions of the grove showed that the dusting method, where the dry dusting sulphur in an exceedingly pulverized form was used, was equally as effective as spraying with lime-sulphur against the avocado red spider. The mites were not killed immediately on the dusted trees, but after 30 minutes were practically all dead. On examination of the foliage with a hand lens the sulphur was found very evenly applied, no portion of the upper surface of the foliage being free from the fine sulphur. The dry sulphur dust adhered remarkably well to the avocado foliage, which has a slightly pubescent surface. The dry sulphur dust remained on the foliage effectively over as long a period of time as did the liquid lime-sulphur against the red-spider mite. This showed that the foliage did not have to be wet with dew, but that the sulphur dust could be applied effectively to the dry foliage.

Where a large acreage of avocados exists, and the red spider is the only pest with which the grower has to contend, dusting is much the quicker method of control. Where the lime-sulphur solution was applied it killed the red spiders by contact almost immediately.

Neither the dry sulphur dust nor the liquid lime-sulphur solution had any effect in ridding the foliage of the thrips present in considerable numbers on the trees. When the red spiders are present there are usually other pests, such as the leaf thrips and avocado lace-bug. To control these by the dusting method the writer procured a dusting material consisting of the finely pulverized sulphur charged with 40 per cent nicotine sulphate. This material was dusted in the same manner as was the dry dusting sulphur. This combination readily killed the adult and immature red spiders, the leaf thrips, and such lace-bugs as were present. The material, however, did not adhere to the foliage for any length of time, even heavy dews removing most of the dust. This apparently was due to the incorporation of the liquid nicotine sulphate into the dry, finely pulverized sulphur, which caused the sulphur particles to aggregate and also formed a wettable sulphur. In the case of the dry sulphur dust the sulphur is in such a dry and impalpable state on the foliage that it adheres effectively. The continued heavy dews gradually removed most of the combination contact insecticide from the foliage and in a short time after application the red spiders were again present on the trees in as

great numbers as before, having been hatched from the eggs which were not destroyed by the dust. It is essential that the dust remain on the foliage for a sufficient length of time after application to destroy the young mites subsequently hatched.

A combination of the lime-sulphur concentrate, at the rate of 1 part to 60 parts of water, plus the 40 per cent nicotine sulphate solution, at the rate of 1 to 900 in the diluted lime-sulphur solution, proved an excellent spray in killing the red spider, thrips, and lace-bug. It also wet thoroughly the branches and killed the young of the dictyospermum scale with which it came in contact. The lime-sulphur solution in this combination proved effective over as long a time as did the lime-sulphur used alone against the red spider on the trees.

CONCLUSIONS RELATIVE TO DUSTING AND SPRAYING.

1. The dusting method with dry sulphur dust in a finely divided form was found to be equally as effective in keeping avocado trees free from red spiders as the spraying method with liquid lime-sulphur solution. When the red spider is the only pest present in the avocado grove the dusting method will prove effective, especially at critical times, as it is much the quicker method. It is not necessary that the foliage of the avocado be wet with dew in order effectively to apply the dry sulphur dust.

2. Sulphur in any of the combinations used did not control the leaf thrips or leafhoppers, but nicotine sulphate solution when combined with either lime-sulphur solution or dry dusting sulphur will destroy them.

3. Dry sulphur dust when charged with nicotine sulphate in the form of 40 per cent nicotine sulphate and applied to avocado foliage was readily removed by heavy dews and light rains after application. Apparently the addition of the liquid nicotine sulphate caused a wettable sulphur. Soon after the first heavy dews, red spiders appeared on the trees where this material had been used, nothing remaining to destroy the young mites as they were hatched from the eggs.

4. Liquid lime-sulphur solution when combined with nicotine sulphate proved to be the most satisfactory combination used in killing both the red spider and leaf thrips and also the lace-bug. The combination remained effective over as long a period as did the lime-sulphur alone against the red spider.

5. Where a grower has a medium sized grove of avocados in which a number of insect pests occur, spraying is the more effective method in combating the evils with which he has to contend.

SUMMARY OF RECOMMENDATIONS.

The dictyospermum scale may be controlled by spraying with an oil-emulsion spray during December, January, and February, using a strength of 1 part emulsion to 70 parts of water. Two applications with a three-week interval are recommended. The same treatment is recommended for the pyriform scale.

The avocado white fly may be controlled by spraying as the foliage is hardening in the fall, usually September, with an oil emulsion at a strength of 1 part to 70 of water and repeating the spray during the spring after the fruit has set, using a strength of 1 to 80. Where the branches are covered with the spray these two applications will suffice against the dictyospermum scale and the pyriform scale.

The blossom Anomala may be controlled by spraying with powdered arsenate of lead at the rate of 1½ pounds to 50 gallons of water. Care should be taken that the spraying outfit is fitted with a suitable agitator.

The avocado blossom thrips may be controlled by spraying with 40 per cent nicotine sulphate solution at the rate of 1 part to 900 parts of water plus 3 pounds of soap to each 100 gallons of the diluted solution. If thrips are abundant spraying should be repeated in from 8 to 10 days.

The avocado leaf-roller may be controlled by spraying with powdered arsenate of lead at the rate of 2 pounds to 100 gallons of water. A good agitator should be fitted to the spray tank to keep the poison in suspension.

The avocado lace-bug may be controlled by spraying with 40 per cent nicotine sulphate solution at the rate of 1 part to 900 parts of water with the addition of 1 or 2 pounds of fish-oil soap to each 50 gallons of the diluted spray.

The avocado red spider and leaf thrips may be controlled while the fruit is still unpicked by using fish-oil soap at the rate of 5 pounds to 100 gallons of water plus 40 per cent nicotine sulphate at the rate of 1 part to 900 parts of the diluted soap solution. After the fruit has been picked and the red spider and thrips are again becoming injurious, lime-sulphur concentrate, 1 part to 60 parts of water or 1 to 75, depending on weather conditions, with the nicotine sulphate solution incorporated at the rate of 1 part to 900 parts of the diluted lime-sulphur solution, may be used. It is recommended that the oil-emulsion sprays should not follow immediately after a spraying of lime-sulphur as the oil-emulsion sprays possess a cleansing quality and remove the lime-sulphur from the foliage. Burning is also likely to result. It is advisable to allow a three-week interval before application of any oil-emulsion spray, in order that the full benefit from the lime-sulphur application may be derived.

Care should be taken when using oil emulsions with "hard" or brackish waters to see that no free oil separation occurs during spraying. Free oil is detrimental to the foliage of the avocado. Where considerable free oil forms in the spray tank, much of the efficiency of the spray is lost, as the oil is the principal killing agent in the oil emulsion.

FOREIGN INSECT ENEMIES OF THE AVOCADO.

The avocado in its native lands has a number of very destructive insect enemies, which, were they to gain entrance to the United States, would prove unquestionably more destructive than any existing in this country at the present time. The Department of Agriculture, being fully aware of the possibilities of the introduction of dangerous foreign avocado pests, has, with the cooperation of the several States where the avocado is now being grown, established rigid quarantines and is doing everything possible to protect this valuable fruit industry.

A very destructive pest liable to introduction into the United States is an avocado weevil [10] occurring in Mexico and Guatemala. In general appearance this weevil, which averages three-fifths of an inch in length, is very dark brown, and the wing covers bear two conspicuous transverse bands of densely placed hairs. It infests the seed of the avocado particularly, but will also feed upon the flesh of the fruit. The larvæ breed and tunnel through the tissues of the seed, making the fruit worthless.

Another dangerous weevil [11] of the avocado with similar destructive characteristics occurs in Guatemala. In general appearance it is shining black in color. The wing covers are moderately clothed with hairs of three colors intermixed—rose-red, rather pale brownish, and a few white. It averages about one-fourth inch in length.

Still another pest of prime importance is the Mediterranean fruit fly.[12] This notorious and widespread enemy of cultivated fruits is present and causes havoc in a few foreign countries where the avocado is grown.

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[10] *Heilipus lauri* Boh.
[11] *Conotrachelus perseae* Barber.
[12] *Ceratitis capitata* Wied.

How To Do It

DO YOU WANT practical suggestions on how to build a silo, a hog house, a poultry house, a potato-storage house, or how to make a fireless cooker, or other farm home convenience? Are you seeking ideas on how to prepare vegetables for the table, how to care for food in the home, how to bake bread and cake and other appetizing foods in an efficient and economical manner? Is there some practical question about your corn or wheat or cotton or other crops, or about your poultry or live stock, to which you are seeking an answer? The answers to thousands of such questions and practical suggestions for doing thousands of things about the farm and home are contained in over 500 Farmers' Bulletins, which can be obtained upon application to the Division of Publications, United States Department of Agriculture, Washington, D. C.